

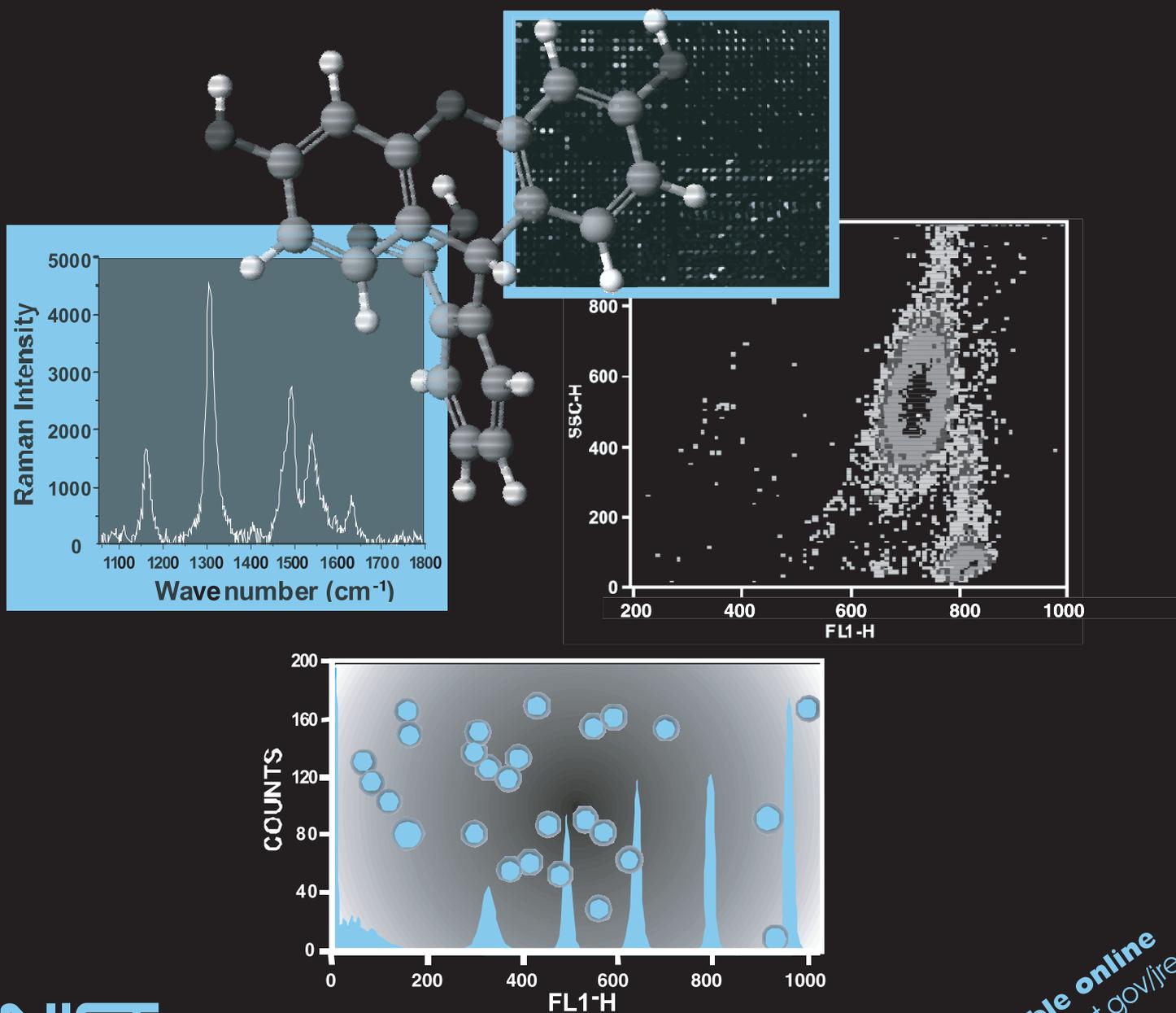
# Journal of Research



of the

# National Institute of Standards and Technology

March-April 2001, Vol. 106, No.2 ISSN 1044-677X



**NIST**

National Institute of Standards and Technology  
Technology Administration, U.S. Department of Commerce

Available online  
<http://www.nist.gov/jres>

**T**he National Institute of Standards and Technology was established in 1988 by Congress to “assist industry in the development of technology . . . needed to improve product quality, to modernize manufacturing processes, to ensure product reliability . . . and to facilitate rapid commercialization . . . of products based on new scientific discoveries.”

NIST, originally founded as the National Bureau of Standards in 1901, works to strengthen U.S. industry’s competitiveness; advance science and engineering; and improve public health, safety, and the environment. One of the agency’s basic functions is to develop, maintain, and retain custody of the national standards of measurement, and provide the means and methods for comparing standards used in science, engineering, manufacturing, commerce, industry, and education with the standards adopted or recognized by the Federal Government.

As an agency of the U.S. Commerce Department’s Technology Administration, NIST conducts basic and applied research in the physical sciences and engineering, and develops measurement techniques, test methods, standards, and related services. The Institute does generic and precompetitive work on new and advanced technologies. NIST’s research facilities are located at Gaithersburg, MD 20899, and at Boulder, CO 80303. Major technical operating units and their principal activities are listed below. For more information contact the Publications and Program Inquiries Desk, 301-975-3058.

---

### **Office of the Director**

- National Quality Program
- International and Academic Affairs

### **Technology Services**

- Standards Services
- Technology Partnerships
- Measurement Services
- Information Services

### **Advanced Technology Program**

- Economic Assessment
- Information Technology and Applications
- Chemistry and Life Sciences
- Materials and Manufacturing Technology
- Electronics and Photonics Technology

### **Manufacturing Extension Partnership Program**

- Regional Programs
- National Programs
- Program Development

### **Electronics and Electrical Engineering Laboratory**

- Microelectronics
- Law Enforcement Standards
- Electricity
- Semiconductor Electronics
- Radio-Frequency Technology<sup>1</sup>
- Electromagnetic Technology<sup>1</sup>
- Optoelectronics<sup>1</sup>

### **Materials Science and Engineering Laboratory**

- Intelligent Processing of Materials
- Ceramics
- Materials Reliability<sup>1</sup>
- Polymers
- Metallurgy
- NIST Center for Neutron Research

### **Chemical Science and Technology Laboratory**

- Biotechnology
- Physical and Chemical Properties<sup>2</sup>
- Analytical Chemistry
- Process Measurements
- Surface and Microanalysis Science

### **Physics Laboratory**

- Electron and Optical Physics
- Atomic Physics
- Optical Technology
- Ionizing Radiation
- Time and Frequency<sup>1</sup>
- Quantum Physics<sup>1</sup>

### **Manufacturing Engineering Laboratory**

- Precision Engineering
- Manufacturing Metrology
- Intelligent Systems
- Fabrication Technology
- Manufacturing Systems Integration

### **Building and Fire Research Laboratory**

- Applied Economics
- Structures
- Building Materials
- Building Environment
- Fire Safety Engineering
- Fire Science

### **Information Technology Laboratory**

- Mathematical and Computational Sciences<sup>2</sup>
- Advanced Network Technologies
- Computer Security
- Information Access
- Convergent Information Systems
- Information Services and Computing
- Software Diagnostics and Conformance Testing
- Statistical Engineering

---

<sup>1</sup>At Boulder, CO 80303.

<sup>2</sup>Some elements at Boulder, CO.

# *Journal of Research of the* **National Institute of Standards and Technology**

---

Volume 106

Number 2

March–April 2001

---

## **Board of Editors**

**Theodore V. Vorburger**  
Chief Editor

**Nancy M. Trahey**, Technology Services

**Loucas G. Christophorou**, Electronics and Electrical Engineering Laboratory

**Theodore V. Vorburger**, Manufacturing Engineering Laboratory

**Cynthia J. Zeissler**, Chemical Science and Technology Laboratory

**Ronald Collé**, Physics Laboratory

**Cynthia K. Montgomery**, Materials Science and Engineering Laboratory

**Nicos S. Martys**, Building and Fire Research Laboratory

**Alan H. Goldfine**, Information Technology Laboratory

**Daniel W. Lozier**, Information Technology Laboratory

**Clifton M. Carey**, Paffenbarger Research Center

*Available online*

<http://www.nist.gov/jres>

## **Julian M. Ives**

Managing Editor, and Technical Production Editor

## **Ilse E. Putman, Karen J. Wick**

Electronic Composition



U.S. Department of Commerce—**Donald L. Evans**, Secretary

Technology Administration—**Karen H. Brown**, Acting Under Secretary of Commerce for Technology

National Institute of Standards and Technology—**Karen H. Brown**, Acting Director

**Cover:** A schematic diagram of the fluorescence intensity quantitation cycle. The bottom panel shows the response of a flow cytometer to a set of five calibration microspheres each with a different amount of immobilized fluorescein. The five peaks provide a calibration line which can be used to assign a “fluorescence intensity” to flow cytometer signals from a population of biological cells, shown in the panel on the right. In analogous fashion, a set of “standard dots” will be used to calibrate the “fluorescence intensity” from a set of dots in a DNA microarray, top panel. The diagram on the left shows the structure of fluorescein, a common fluorochrome used in biological assays. The Raman spectrum of fluorescein, left panel, is one of several measurements that can be performed to understand the behavior of the fluorochrome on materials such as standard microspheres. Cover illustration by C. Carey.

The *Journal of Research of the National Institute of Standards and Technology*, the flagship periodic publication of the national metrology institute of the United States, features advances in metrology and related fields of physical science, engineering, applied mathematics, statistics, and information technology that reflect the scientific and technical programs of the Institute. The *Journal* publishes papers on instrumentation for making accurate measurements, mathematical models of physical phenomena, including computational models, critical data, calibration techniques, well-characterized reference materials, and quality assurance programs that report the results of current NIST work in these areas. Occasionally, a Special Issue of the *Journal* is devoted to papers on a single topic. Also appearing on occasion are review articles and reports on conferences and workshops sponsored in whole or in part by NIST.

---

ISSN 1044-677X

Coden: JRITF

Library of Congress Catalog Card No.: 89-656121

---

United States Government Printing Office, Washington: 2001

## *Note to Readers*

Dear Reader,

I am honored to succeed Barry N. Taylor as Chief Editor of the *Journal of Research of the National Institute of Standards and Technology*. Barry has served the *Journal* and NIST with distinction both through his encouragement of NIST authors to submit accounts of their excellent work and through the high standards he applied to the daily job of reviewing and improving the manuscripts submitted. Although it has undergone several name changes, the *Journal* has been in continuous existence since 1904, a few years less than NIST itself. Thanks to Barry and the Board of Editors, I am taking on the job of Chief Editor during an active time in the *Journal's* history. The excellent collection of fundamental articles in the Centennial Issue, January-February of this year, and the numerous fine manuscripts in the pipeline for current and upcoming issues indicate that the *Journal* is thriving as the principal publication for archival articles on key NIST measurement results, methods, instruments, and modeling in science, engineering, and information technology. I will foster important contributions as Barry did and will continue to publicize the whole breadth of activities of our unique institution in the News Briefs.

**Theodore Vorburger**  
Chief Editor

## *Message From Past Chief Editor*

Dear Reader,

With this issue (Volume 106, No. 2, March–April 2001), Theodore Vorburger succeeds me as Chief Editor of the *Journal of Research of the National Institute of Standards and Technology*. It has been my pleasure to serve as Chief Editor of the *Journal*, the flagship periodic publication of the national metrology institute of the United States, for a little over 12 years. (My first issue was Volume 94, No. 1, January–February, 1989.) During this time, I, together with the other members of the Board of Editors of the *Journal*, attempted to bring to the *Journal's* readers outstanding papers that reflected the diverse scientific and technical programs of NIST, as well as succinct descriptions via the News Briefs of the most exciting current work of the NIST staff. I am pleased to be able to assure you that Ted plans to continue to the utmost of his outstanding abilities this long tradition of the *Journal* and its predecessors and, as a result, that you will continue to find each issue worthy of your attention.

**Barry N. Taylor**

# Contents

*Available online*  
<http://www.nist.gov/jres>

Note to Readers	iii
Message From Past Chief Editor	iv

## Articles

---

A Careful Consideration of the Calibration Concept	<b>S. D. Phillips, W. T. Estler, T. Doiron, K. R. Eberhardt, and M. S. Levenson</b>	371
The Development of Fluorescence Intensity Standards	<b>A. K. Gaigalas, Li Li, O. Henderson, R. Vogt, J. Barr, G. Marti, J. Weaver, and A. Schwartz</b>	381
Concrete Mixing Methods and Concrete Mixers: State of the Art	<b>Chiara F. Ferraris</b>	391
Distribution of Link Distances in a Wireless Network	<b>Leonard E. Miller</b>	401
Information Model for Machine-Tool-Performance Tests	<b>Y. Tina Lee, Johannes A. Soons, and M. Alkan Donmez</b>	413
Global and Local Optimization Algorithms for Optimal Signal Set Design	<b>Anthony J. Kearsley</b>	441
Video Transmission for Third Generation Wireless Communication Systems	<b>H. Gharavi and S. M. Alamouti</b>	455
Treasure of the Past VI: Standard Potential of the Silver-Silver-Chloride Electrode from 0° to 95 °C and the Thermodynamic Properties of Dilute Hydrochloric Acid Solutions	<b>Roger G. Bates and Vincent E. Bower</b>	471

---

## News Briefs

---

<b>GENERAL DEVELOPMENTS</b>	479
NIST Develops Randomness Tests for Random and Pseudorandom Number Generators Used in Cryptographic Applications	
European Acceptance of NIST-Recommended Conformity Assessment Bodies (CABs)	
Flammability Assessment Methodology for Mattresses	
Breakthrough in Question-Answering at the Ninth Text Retrieval Conference (TREC-9)	480
New Insights Into Wear-Out Mechanisms of Ultra-Thin Silicon Dioxide Gate Dielectrics	
Fighting Fire With Fire Products	
NIST Helps Demonstrate Mobile-Code Control	481

---

Interoperable MPI Standard Demonstrated NIST Researchers Release Public-Domain Dynamic Source Routing Model NIST Develops Photometric and Colorimetric Standards for LEDs	482
NIST Provides Insight Into Magnetic Coupling Through Antiferromagnets NIST Granted Patent for a Compact Compressor for Polarized <sup>3</sup> He Gas Supercooling and Superheating of Vortex Matter	483
Supercooling and Superheating of Vortex Matter Pinning Magnetization by a Special Thin-Film Deposition Technique Advances in Process Visualization Reveals Novel Polymer Structure NIST Hosts Metadata Committees	484
NIST Co-Sponsors Large-Scale Network Research Planning Workshop NIST Hosts Topic Detection and Tracking (TDT) Workshop on Text Organization NIST Hosts NCITS Standards Committee on Information Technology (IT) Accommodation	485
NIST Hosts Ninth Text Retrieval Workshop (TREC-9) NIST Sponsors Industry Usability Reporting Workshop NIST Co-Hosts International Laboratory Accreditation Cooperation (ILAC) 2000	486
NIST Hosts Training Session on MEASUREnet-gov System Keeping Tabs on the Site With Laser Light April Conference to Showcase 2000 Baldrige Recipients	487
Polish Up Your Gloss Measurements at NIST Tests Certify “Smart” Building Products New Book, Web Site Can Help Media Feature NIST at 100	488
NIST Reference Implementation to be Used Throughout Veterans Health Administration Calibration Standards for Determination of Molecular Mass Key NIST Contributions Result in Deployment of New E-Commerce Standards Supporting Electronics Manufacturing	489
NIST’s Test Tools for Internet Telephony Will Help Industry Converge Disjoint Applications Electrodeposited Pb-Free Solder and Whisker Prevention Characterizing Nanoscopic Disorder Using Quantum Molecular Tops	490
Improving Crystal Resonators With New Materials Neural Network Technique Used for Modeling Nonlinear Error Data Very Low-Noise Single Electron Tunneling Transistors	491
100 mV Peak Output Demonstrated for the Josephson Waveform Synthesizer New X-Ray Absorption Technique to Study Concrete NIST Develops New Form of Neutron Radiography Providing Fine Internal Details	492
Compact Frequency Standard Driven by a Diode Laser Developed by NIST An Optical-Fiber Network for Frequency Comparisons Established in Boulder Stick-Slip Motion of a Stressed Coulomb Crystal Observed by NIST Scientists	493

---

Determination of the Relativistic Red Shift by NIST in Boulder NIST Performs Comparison of NIST Frequency Standards NIST Scientists Develop Decoherence-Resistant Quantum Memory Using Trapped Ions	494
Test of Bell’s Inequalities Using Trapped Ions Solar Cell Electron Transfer Dynamics Measured by NIST Scientists NIST Develops Benchmarking Web Site Usability Methodologies (CIFter)	495
NIST Researchers Demonstrate Software to Model Fault Recovery in Optical Networks NIST Develops Data Libraries for Airflow Modeling Designer Channels for Microfluidic Devices	496
Prediction of the Atmospheric Lifetimes of Halon Replacements NIST/FIZ-Karlsruhe Partnership to Improve the Inorganic Crystal Structure Database for Materials Research	497
NIST Hosts RTP 2000 and Related Workshop NIST Digital Cinema 2001 Conference Draws Industry to Discuss Standards	498
NIST Hosts MPEG Web Site MMD Hosts Smart Sensor Industry Workshop Just a Phase? Better Neutron Analysis With Lower Radiation	499
NIST, ANSI Reaffirm Partnership for U.S. Standards Success NIST/Industry Consortium to Tackle Complex Polymer Interphases New Version of Charpy Machine Guide Is Now Available	500
Short Course on Radiation Thermometer Measurement Offered SET for Fundamental Measurements in Electricity Explained	501
NIST Data Facilitate Materials Development for Next Generation IC Chip NIST Performs First Measurements of the Effect of Stress on the Refractive Index of Materials in the Vacuum Ultraviolet Non-Linear Network Analysis Facility Established	502
New Excimer Laser Measurement Services at NIST Coordinate Measuring Machine Streamlines Diameter Measurements Calibration of Transfer Ionization Chambers for Short-Lived Radionuclides Used in Nuclear Medicine Developed by NIST	503
NIST Developing Optical Technologies for Assessing Structures of Chiral Molecules A New “Twist” on Neutron Reflectometry: Imaging Exchange-Spring Magnets	504
NIST Leads Effort to Update and Standardize Certification Procedures in the Federal Government Publication of <i>Characterization and Metrology for ULSI Technology: 2000</i> (AIP Conference Proceedings 550)	505
Mass Metrology Training Seminar NIST Conducts Wafer Flatness Workshop NIST Hosts Computer Security Advisory Board Alliances Formed in Nanotribology for Magnetic Data Storage Technology	506

---

NIST Hosts Workshop on Thermal Spray Process Reliability New Technique for Blending Polymers Yields Novel Structures	507
New Tool for Identifying Vulnerabilities Up and Running Baldrige Criteria Can Help Assess, Improve . . . and Go for the Gold March Symposium Sizes Up the Past, Future of Standards	508
European Directive on Medical Testing Demands Traceability NIST Assesses Reduced Ignition Propensity Cigarette for FTC Virtual Lab Consortium to Test Concrete and Cement Formulas	509

---